Network Time Protocol Client

It's about TIME!

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Local stations have always maintained correct time-of-day, derived from an NBS satellite clock receiver that transmits via RS-232 a 13-character Ascii message that is interpreted by one of the stations on the network, which then broadcasts the result to the rest. To use this system in another place, one would need to purchase such a radio receiver. But with the widespread use of Internet, another scheme taking advantage of the Network Time Protocol to access a server seems an easier means to get the time-of-day. This note describes an implementation of an NTP client as a local application. It periodically queries an NTP server, interprets the reply, and updates the local time-of-day. Between queries, the time-of-day is maintained via timing based upon a crystal on the CPU board.

The NTP protocol is a simple client server model. A client sends a simple request addressed to UDP port# 123 of an NTP server node. The server returns a reply that includes an 8-byte time-of-day that consists of a 4-byte integer number of seconds and a 4-byte fraction. The time value is based upon January 1, 1900. Since some time in 1968, the value of this 8-byte quantity has been negative; *i.e.*, the number of seconds since 1900 has been more than 2^{31}. The value will "roll over" in 2036. In the meantime, we should be able to talk about time-of-day reasonably accurately.

The parameters used by this local application are as follows:

```
E LOC APPL PARAMS 03/29/94 0854
NODE<0576>  NTRY<12>
NAME=TIME   CNTR=00A5
TITL"TIME-OF-DAY SERVER QUERY"
SVAR=0004A280
ENABLE  B<00BF> TIME ENABLE
QPERIOD  <003C>
IPADDRHI <83E1>
IPADDRLO <7C28>
RETRIES  <0003>
ZONEGMT+ <FFFA>
TARGNODE <0000>
```

Every local application has an enable bit as the first parameter. The second parameter for the TIME local application is the period between queries expressed in seconds. (For example, 003C = 60 seconds.) The next two word parameters comprise the IP address of the NTP server to be queried. Here, 83E17C28 is 131.225.124.40, the IP address of CNS33, a Fermilab NTP server. Next is the number of retries before timing out. Next is the time zone correction in hours relative to GMT, which depends upon whether Daylight Savings Time is in effect. Finally is given the multicast target node# for sharing this news with other local stations on the network.

Now for the details. The Network Time Protocol is described in RFC-1305 in 300K of detail. A much easier treatment is in RFC-1361, describing the Simple Network Time Protocol that is suitable for end user clients. SNTP uses the NTP in a simple way. This SNTP variation is used by the TIME local application.

The message format is 15 longwords, or 60 bytes, in length. In the SNTP variation query format, the first byte is 0x0B, with all other bytes zero. The meaning of this first byte is that the Version Number = 1, and the Mode = client. Version 3 of NTP is described in RFC-1305, Version 2 in RFC-1119, and Version 1 in RFC-1059. There was a Version 0 described in RFC-959

that is no longer supported by NTP servers. An NTP server that supports Version "n" also supports lower versions down to 1.

The reply to such a query is up to 60 bytes in length, where the 8-byte Transmit Timestamp is extracted for interpretation as the present time-of-day. It is found 40 bytes deep into the message. To convert this form into the time-of-day requires some work. The TIME local application may not be the best example of how to do it. But here is a description of its current implementation:

Empirically, it has been determined that the value of seconds since the start of 1994 is `0xB0CF3B80`, or 2966371200. This value assumes the Greenwich Mean Time zone, which is 6 hours ahead of Central Standard Time. The software subtracts this 1994 base from the Timestamp value and derives the rest of the month, day, hour, minute and second from the rest. If more than a year has passed since 1994 (January 1, 1995, or later), it assumes 365 or 366 days of seconds per year. Our calendar system is not quite perfect, so that the time-of-day in some years has an extra "leap second" inserted after the last day of the year. The Timestamp returned by NTP servers, however, does *not* include any such "leap second," so the time-of-day produced by TIME should be ok for subsequent years. (This is explained in RFC-1305.)

Once the conversion has been made, the local record of the time-of-day, in BCD at memory address `0x00000788`, is set to the current time. Then, if the target node parameter is nonzero, a message is prepared using Classic Protocol to send it to the local stations on the same network. The address that is used for this depends upon a table of transmittable multicast addresses in the TRING table in non-volatile memory. This table of 8-byte entries is at address `0x00105B80` in 133-based local stations and at address `0x00405B80` in 162-based stations and Internet Rack Monitors.

A timeout of 2 seconds is allowed before assuming no response from a server. This is a constant in the TIME local application. The number of retries parameter should allow for a timely response very soon, however, in case routers need to perform ARPs, say, and fail to pass an unexpected frame the first time.